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WATERTOWN ARSENAL LABORATORY

ATI 38776

6/19/90

EXPERIMENTAL REPORT

NO. WAL. 640/90

WELDING OF ARMOR

Summary of Ballistic Shock Test Results on
1/2, 3/8, and 1/4 Inch Thick Homogeneous Armor "H" Plates Welded with
Austenitic Electrodes and Tested at Aberdeen Proving Ground
during the Period from 1 October 1942 through 31 March 1943

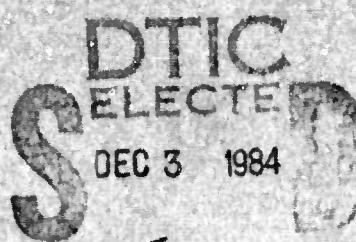
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WATERTOWN ARSENAL
WATERTOWN, MASS.

DATE 17 November 1943

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No. WAL 640/90

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Watertown Arsenal Laboratory
Report Number WAL 640/90
Problem D-3.2

17 November 1943

WELDING OF ARMOR

Summary of Ballistic Shock Test Results on
1/2, 3/8, and 1/4 Inch Thick Homogeneous Armor "H" Plates
Welded with Austenitic Electrodes and Tested at
Aberdeen Proving Ground during the Period from
1 October 1942 through 31 March 1943

OBJECT

To tabulate firing record data for subject plates and to
present a comparison of ballistic shock performance of plates
made with various materials and welding procedures.

SUMMARY

1. Data from Aberdeen Proving Ground firing records for 99 welded armor H plates have been tabulated on accompanying charts and tables.
2. Quality of armor plate appears to be the most significant variable for the three thicknesses of plate included in the tabulation.
3. There is little difference in ballistic shock test results between plates welded with the manganese and with the molybdenum modified type of austenitic electrodes. No significant trends for decreased weld cracking during ballistic testing are apparent for any of the variations in joint preparation or welding procedure.

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INTRODUCTION

On the accompanying charts (Appendix A) are tabulated data taken from firing records representing qualification and development tests of 99 H plates. The tabulation includes all firing records received by this arsenal for H plates assembled from 1/2, 3/8, and 1/4 inch thick homogeneous armor by welding with austenitic electrodes and fired at Aberdeen Proving Ground during the period from 1 October 1942 through 31 March 1943.

Previous reports (WAL 640/84 and 640/89) have summarized ballistic test results for 1-1/2, 1, and 3/4 inch cast and rolled homogeneous armor H plates welded with austenitic electrodes and tested at Aberdeen Proving Ground during the same period as that covered by this report. An earlier report (WAL 640/73) dealt with 1-1/2 and 1 inch thick armor H plates welded with ferritic electrodes and tested at Aberdeen Proving Ground prior to 25 February 1943.

An index to fabricators, armor manufacturers, and electrode manufacturers is given in Table I. A summary of ballistic shock test specification requirements for H plates welded with austenitic electrodes and a key to the tabulation methods and symbols used in this report are included in Appendix A.

GENERAL COMMENTS

Ballistic performance of H plates is best evaluated by amount of cracking for each round, but the cracking is influenced by the variables in the ballistic test as well as those introduced by the materials and welding procedure. The majority of the plates included in this tabulation were tested with a 37 mm. high explosive, projectile. This projectile is fired at a velocity which would result in a complete penetration of the plate if the high explosive charge in the projectile did not detonate before this happened. The use of higher velocities permits greater accuracy of firing. The energy delivered to the plate by the high explosive charge produces a considerable area of plate deformation without piercing the plate.

Lighter gages of plate are able to bow or deform more on projectile impact than 1 inch and heavier plates, so that the shock wave is probably dissipated more generally and the test is therefore somewhat less critical in showing up certain types of weld defects than for the heavy plates.

Table II shows the average plate and weld cracking in terms of variations in the conditions of ballistic testing. If the distance from the center of the impact to the center of weld is greater than 1-3/4 inches, the impact is not considered as a fair test of the weld.

In the summary tables that follow, the number of rounds outside the specification limit for velocity and location will be listed under remarks, and should be taken into consideration in comparing

effects of armor and welding variables. The effect of including these rounds in the averages is to lower the average cracking, but since a considerable amount of cracking was caused by unfair rounds, and since the proportion of fair to unfair rounds was approximately the same for any group of plates, the averages as shown appear to be suitable for indicating the more obvious effects of welding materials and procedures on ballistic performance. Cracking within 1/8 inch of the weld is included as weld cracking and the remainder as plate cracking. Inasmuch as virgin armor would not ordinarily develop cracking under the same testing conditions as those used for the H plate, and since development of plate cracking materially decreases the severity of the test on welds, it is necessary to consider plate cracking in evaluating performance of welded H plates.

HAND WELDED, 1/2 AND 3/4 INCH THICK ROLLED ARMOR H PLATES

Tables III through XIV show comparisons of average cracking per round for all the plates included in this tabulation in terms of welding fabricator, armor manufacturer and processing, electrode data, joint design, welding procedure, and radiographic soundness.

Fabricators - Tables III and IX

The performance of H plates welded by any one fabricator must be evaluated in terms of armor and electrodes used, as well as the welding procedure and inspection control.

Armor Data - Tables IV and X

The 1/2 inch plates include both machineable homogeneous and hard homogeneous armor. Since the two types overlap and a number of the plates could qualify as either type, all have been grouped together for this tabulation.

With the exception of two 3/8 inch thick, high carbon-manganese plates which cracked badly, no correlation is evident between chemical composition of the armor plate and ballistic performance. A high ratio of plate to weld cracking for some of the armor types is indicative of poor steel quality (cleanliness and directional properties). Previous tabulations (WAL 640/84) have shown that this variable may also affect amount of weld cracking.

Plate and weld cracking tend to increase with hardness of armor plate unless there has been a commensurate improvement in steel quality. The Ingersoll Steel 1/2 inch thick plates are an example of relatively good plate performance at high hardness level.

Electrodes - Tables V and XI

Firing record data on electrode compositions and coatings very frequently were incomplete or questionable. When an electrode was used on a small number of plates, the average weld cracking may have

been influenced unduly by other factors. There is little difference in ballistic performance between plates welded with Mn-Mo modified (weld analysis at least 1% Mn and .2% Mo) austenitic electrodes, and those with Mn modified (weld analysis at least 1% Mn and no Mo) austenitic electrodes.

Joint Design - Tables VI and XII

Double V joint preparation with 60° or 90° included angle appears superior to single V joints with 45° or 60° included angle for 1/2 inch plate, but a single V with 60° included angle is slightly superior for 3/8 inch plate. Root gap does not appear to be an important variable for these plates. The use of a copper backup strip appears advantageous for 1/2 inch plates, but not for the 3/8 inch plates.

Welding Procedure - Tables VII and XIII

The majority of both groups of plates were welded with 3 passes. Increase in number of passes for either the single or double V joint preparation does not correlate with any definite trend in ballistic performance.

The use of a combination of weaves and beads with multiple crown deposit appears more desirable than a full weave technique for the 1/2 inch plates, but a straight weave technique was quite satisfactory for 3/8 inch thick plates. Nine 1/2 inch plates with a single V bevel were welded with the first pass deposited from the back of the joint against a round brass backup bar. The welding of these plates was then completed from the front. All remaining single V plates employed a seal bead. Average weld cracking in the ballistic test is slightly less for the plates welded with a seal bead.

A preheat of 250° F. was used during welding of 14 of the 1/2 inch thick H plates. All remaining plates were welded with initial plate temperature between 70° and 110° F. Improvement in average weld cracking is shown for these preheated plates.

Although radiographic unsoundness is usually associated with increased weld cracking during the ballistic test, these two groups of plates show greater weld cracking for the plates which passed radiographic inspection than for those which failed, indicating that other factors were of greater importance for these particular plates.

HAND WELDED, 1/4 INCH THICK ROLLED ARMOR H PLATES

Seven H plates were welded with 1/4 inch thick rolled homogeneous armor plate (Charts Nos. 36 - 39). Four of the plates were tested with the 37 mm. H.E. M-54 projectile, and three plates with the 20 mm. H.E.1 MK.1 projectile. A high proportion of plate cracking was developed during ballistic testing for two of the four armor compositions used, indicating the importance of steel quality. No comparison of welding variables is possible for the limited number of plates. No preheating was used and all plates passed radiographic inspection.

TABLE 1

Index to Plates

Hand Welded 1/2 Inch Thick H Plates

Chart No.	No. of Plates	Fabricator	Armor Mfgr.	Electrode Mfgr.
1	1	American Car & Fdry.	Jones & Laughlin	McKay
2-3	4	American Locomotive	Great Lakes Youngstown Follansbee	Alloy Rods Harnischfeger
4-5	5	Buick	Youngstown Great Lakes	Alloy Rods Harnischfeger
6	3	Ford	Ford	Crucible Arcos
7	2	General Motors	Youngstown Great Lakes Jones & Laughlin	Lincoln Electric McKay
8-13	18	Harmon-Herrington	Great Lakes Ingersoll	McKay
14	3	So. Calif. Div. of G.M.	Great Lakes	Page-Allegheny McKay

Hand Welded 3/8 Inch Thick Rolled Homogeneous H Plates

15	1	American Car & Fdry.	Jones & Laughlin	McKay
16	2	Buick	Republic	Alloy Rods
17-29	36	Chevrolet	Chevrolet Forge Great Lakes Youngstown Jones & Laughlin E.C. Atkins	Crucible Alloy Rods Harnischfeger McKay
30	2	Deere & Co.	Standard Steel Jones & Laughlin	Lincoln Electric Crucible

TABLE 1 (cont.)

Chart No.	No. of Plates	Fabricator	Armor Mfgr.	Electrode Mfgr.
31-35	15	Ford	Ford	Crucible Hollup Arcos Page-Allegheny
<u>Hand Welded 1/4 Inch Thick Rolled Homogeneous H Plates</u>				
36-37	4	Buick	Youngstown Great Lakes Jones & Laughlin	Alloy Rods Harnischfeger
38-39	3	Ford	Ford	Crucible

TABLE II a

Ballistic Severity Table for 1/2 Inch Thick Rolled Homogeneous Armor H Plates

Vel. f/s 2600	No. of Rounds	1st Round		2nd Round		3rd Round	
		Av. Plate (Inches)	Av. Yield Cracking (Inches)	Av. Plate (Inches)	Av. Yield Cracking (Inches)	Av. Plate (Inches)	Av. Yield Cracking (Inches)
<u>Projectile 37 MM HE M-54</u>							
1-7/16"	8	3.5	9.8	8	8.5	7.9	8
1-7/16 - 3"	3	1.6	0	5	0	0.6	2
over 3"	7	0	0	4	0	0	3
<u>4th Round</u>							
1-3/4"	2	0	0.6				
1-3/4-3"	2	0	0				
over 3"	2600	1	0	0	0	0	0
<u>5th Round</u>							

*Distance from center of impact to center of weld

TABLE III b

Ballistic Severity Table for 1/2 Inch Thick Hard Homogeneous Armor H Plates

Weld Slope Degrees	No. of Welds	No. of Cracking Rounds	Av. Plate Thickness (Inches)	1st Round		2nd Round		3rd Round	
				No. of Welds	Av. Plate Thickness (Inches)	No. of Welds	Av. Plate Thickness (Inches)	No. of Welds	Av. Plate Thickness (Inches)
<u>Projectile 37 MM HE I-54</u>									
1-3/4"									
2100	2	0	5.5	2	0	14.8			
2300	6	1.2	9.9	7	1.3	9.5	6	14.3	13.3
2600									
<u>1-3/4" - 3"</u>									
2100	2	0	0						
2300	1	0	0						
2600	3	2.3	2.9	5	1.4	3.1	1	0	0
over 7"									
2100	1	0	0						
2300									
2600	3	0	0	1	0	0	0	0	0

*Distance from center of impact to center of weld

TABLE II b (Cont.)

Vol. f/s	No. of Rounds	4th Round			5th Round		
		Av. Plate Cracking (Inches)	Av. Weld Cracking (Inches)	No. of Rounds Cracking (Inches)	Av. Plate Cracking (Inches)	Av. Weld Cracking (Inches)	No. of Rounds Cracking (Inches)
<u>Projectile 37 Mi E2 W-54</u>							
2300	1	0	8.0	0	2	0	10.3
2600	5	1.2	7.1	0			
<u>1-3/4 - 3"</u>							
2300	1	1.0	9.0	1	7.0	13.3	
2600							

*Distance from center of impact to center of weld

TABLE II C

Ballistic Severity Table for 3/8 Inch Thick Rolled Homogeneous Armor Plates

Vel. ft/s	No. of Rounds	1st Round			2nd Round			3rd Round		
		Av. Plate Cracking (Inches)	Av. Plate Cracking (Inches)	No. of Rounds Cracking (Inches)	Av. Plate Cracking (Inches)	Av. Plate Cracking (Inches)	No. of Rounds Cracking (Inches)	Av. Plate Cracking (Inches)	Av. Plate Cracking (Inches)	No. of Rounds Cracking (Inches)
<u>Projectile 37 MM HE M-54</u>										
1-3 1/4"	2	0	4.8	19	0.2	10.0	8	3.9	6.8	
2000	2	0	8.1	12	6.3	15.4	7	9.9	12.9	
2100	32	2.0	12.0							
2300	1	22.0								
<u>1-3 1/4 - 3"</u> *										
2000	1	0	0	11	1.1	1.0	5	0	0.1	
2100	12	2.0	1.7	5	0.2	0.2	1	0	1.0	
2300										
<u>over 3"</u> *										
2000	8	2.9	1.2	5	0	0.4	4	0	0.4	
2100				1	35.8	0	1	0	5.3	
2300										

*Distance from center of impact to center of weld

TABLE II c (Cont.)

Vel. f/s	No. of Rounds	4th Round			5th Round			6th Round		
		No. of Cracking	Av. Plate	Av. Yield	No. of Cracking	Av. Plate	Av. Weld	No. of Cracking	Av. Plate	Av. Weld
		(Inches)	(Inches)	(Inches)	(Inches)	(Inches)	(Inches)	(Inches)	(Inches)	(Inches)
<u>Projectile 77M; HE M-54</u>										
1-3/4**										
2100	9	1.1	1.5	1	1.0	0	3	0	1.0	
2300	1	0	14.3							
<u>1-3/4 - 3**</u>										
2100	2	0	0	2	0	0	1	0	0	
2300										
<u>over 3**</u>										
2100										
2300										

*Distance from center of impact to center of weld

TABLE II d
Ballistic Severity Table for 1/4 Inch Thick Rolled Homogeneous Armor H Plates

Weld. if/s	No. of Rounds Cracking	Cracking (Inches)	1st Round		2nd Round		3rd Round		4th Round	
			No. of Av. Plate	Av. Weld						
<u>Projectile 37 MM HEI MK4</u>										
1-3/4"	2	0	0	4	8.3	9.4	1	0	36.0	
1-3/4 - 3"	2	0	0	4	8.3	9.4	1	0	36.0	
1500	2	0	0	4	8.3	9.4	1	0	36.0	
<u>Projectile 20 MM HEI MK1</u>										
1-3/4"					1	4.8	0	0.5	3.0	
1500-1600					1	0	0.8	1	1	0
1500-1700	1	0	0	0	1	0	0	0	6.5	
1700-1800+1	1	8.0	0	1	0	0	2	3.1	7.5	
1-3/4 - 3"					1	4.3	0	2.4	1	0
1500-1600	1	4.8	0	0	1	0	0	0	0	
1600-1700					1	0	0	0	0	
1700-1800					1	0	0	0	0	

*Distance from center of impact to center of weld

TABLE II a (Cont.)

Weld Proj. I/s (Inches)	Weld Cracking (Inches)	No. of Av. Welds	No. of Av. Plate Av.	No. of Av. Plate Av.	6th Round		7th Round		8th Round	
					Cracking (Inches)	Rounds	Cracking (Inches)	Rounds	Cracking (Inches)	Rounds
<u>Projectile 20 M. E.I. M.L</u>										
1-3/4"										
1500-1600										
1600-1700	1	0	0	0						
1700-1800+	1	0	0	0						
1-3/4-3"										
1600-1700					1	5.8	0	0	0	0
over 3"										
1700-1800+					1	0	0	0	0	0

*Distance from center of impact to center of weld

TABLE III
 Fabricators of End Welded 1/2 Inch Thick Armor H Plates

Fabricators	No. of Plates	No. of Rounds	Avg. Weld Crk/rd	Avg. Plate Crk/rd	Remarks
			(Inches)	(Inches)	
Am. Car & Foundry.	1	1	3.0	0	2 rds. outside 1 3/4" limit
Am. Locomotive	4	12	6.5	1.5	6 rds. outside 1 3/4" limit
Buick Motor	5	11	6.5	7.6	4 rds. outside 1 3/4" limit
Ford Motor	5	10	5.7	1.1	5 rds. outside 1 3/4" limit
General Motors	2	6	1.2	0	2 rds. outside 1 3/4" limit
Harron-Herrington Co.	18	56	6.4	1.2	24 rds. outside 1 3/4" limit 11 rds. below spec. vel.
So. Cal. Div. of General Motors	3	10	1.2	2.5	7 rds. outside 1 3/4" limit

TABLE IV
Armor Data for Hand Welded 1/2 Inch Thick Rolled Armor F Plates

Mfr.	Type	Chemical Composition	Heat Treatment	No. of Plates	No. of Welds	Av. Crkr./Rd.	Remarks
				(Inches)	(Inches)		
Tollansbee	III	.24 C .148 Mn .19 Si .15 Cr .50 Mo	1640 980 1 1 1	350- 352 Water Air	1 3 3 3 10	1.1 3 10 1.1 1.1	5.6 5 rds. outside 1 3/4" limit
Steel Co.	Iron-Mo						
Ford	II	.27 - .88 - .24 - .46 - .42 -	.28 C 1.34 Mn .28 Si 1.95 Cr .44 Mo	1550 975 3/4 - 1/2 Water Air	2 Platen 3/4 3 3		
	Iron-Cr-Mo						
Great Lakes	IV	.29 - .83 - .68 - .53 - .15 - .07 -	.33 C .97 Mn .80 Si .75 Cr .24 Mo .11 Zr	1600- 1700 650- 1000 1/2- 2	1/2- 2-1/4 Water Air	45 16 45	1.9 23 rds. outside 1 3/4" limit 2 rds. below spec. vel.
	Iron-Cr-Si						
Ingersoll	VI	.29 - .15 - .80 - .83 - .43 -	.30 C .95 Mn .87 Si .1.02 Cr .45 Mo	1600 900- 1000 1- 2	1-1/2 Water 1 2	24 6	4.3 9 rds. outside 1 3/4" limit 0.3 9 rds. below spec. vel.
	Mn-Si-Cr-Ni-Mo						

TABLE IV (Cont.)

Ref.	Furn.	Chemical Composition	Heat Treatment	No. of BEN Plates	No. of Weld Rds.	Av. Crks./Rd.	Remarks
		%	°F Hrs. Hold Quench	(Inches)	(Inches)		
Jones & Laughlin	III In-Mo	.25 C 1.46 Mn .22 Si .45 Mo	1625 925 2	1 Water 335- 341	1 - 4	3.0 0	2 rds. outside 1 3/4" limit
Youngstown	III Mn-Mo	.22 - .25 C 1.38 - 1.52 Mn .16 - .22 Si .15 - .50 Mo	1600- 1640 785- 840	1/2- 1-1/2 1/2- 1	Water 341- 388 Air	6 15	6.6 5.8 7 rds. outside 1 3/4" limit
Sheet & Tube Co.							

TABLE V

Electrode Data for Hand Welded 1/2 Inch Thick Rolled Armor Plates

Infer.	Brand	Weld Metal Comn.	Coating	Plates	No. Rds.	Average Weld cracking per rd. (Inches)	Average Plate cracking per rd. (Inches)	Remarks
Alloy Rods	Armorarc B	.10 C 1.8 Mn .50 Si 20. Cr 9.5 Ni 2.5 Mo	Titania	1	3	3.3	4.9	1 rd. outside 1 3/4" limit
		.08 - 1.04 - .22 - 18.51 - 9.79 - 2.01 - .04 - .05 -	Lime	4	8	6.3	10.5	3 rds. outside 1 3/4" limit
Arco's	Chromang	Not Given		1	4	3.8	1.3	2 rds. outside 1 3/4" limit
Crucible	Armorite Rezistol	.07 C 1.82 Mn 20. Cr 10. Ni 2.0 Mo	Titania	2	6	6.9	0.9	3 rds. outside 1 3/4" limit

TABLE V (Cont.)

Mfr.	Brand	weld metal Comp.	Coating	No. Plates	No. Rds.	Average Weld cracking (Inches)	Average Plate cracking per rd. (Inches)	Average Weld cracking per rd. (Inches)	Remarks
Barnisch-Feger	AN 3	1.44 - .47 - .47 - 18.1 - 10.2 - 1.61 - .05	.15 C Mn Si Cr. Ni Mo V Cu	Lime	2	7	4.6	0	4 rds. outside 1 3/4" limit
Lincoln	Armorweld			Lime	1	3	2.3	0	2 rds. outside 1 3/4" limit
McKay	Armorloy ▲ 5			Lime	2	7	1.7	0	2 rds. outside 1 3/4" limit

TABLE V (Cont.)

Mfr.	Brand	Yield Metal Comp.	Coating Plates	No. Rds.	Average Weld cracking per rd. (Inches)	Average Plate cracking per rd. (Inches)	Remarks
Armorloy	▲ 5	.10 - .12 C .78 - 4.20 Mn .33 - .49 Si 19.3 - 20.1 Cr 9.6 - 10.2 Ni	Lime	18	56 5.4	1.2	2 1/4 rds. outside 1 3/4" limit 11 rds. below spec. vel.
Armorloy		.9 - .11 C .6 - .45 - .70 Si 19.2 - 19.9 Cr 10.15 - Ni .98 - 1.0 Mo	Lime	1	5 0	2.7	5 rds. outside 1 3/4" limit
Armorloy		.10 - .15 C .75 - 4.02 Mn .49 - .53 Si 19.63 - 20.46 Cr 10.05 - 10.28 Ni	Lime	1	3 3	3.2	2 rds. outside 1 3/4" limit
Page	Stainless	.13 - .15 C 3.62 - 4.52 Mn .18 - .25 Si 18.9 - 20.2 Cr 11.27 - Ni	Lime	1	2	0.9	0

TABLE VI
Joint Design Data for 1/2 Inch Thick Rolled Armor H Plates

<u>Angle of Bevel</u>	<u>No. of Plates</u>	<u>No. of Rounds</u>	<u>Av. W. Cr/rd.</u>	<u>Av. Pl. Cr/rd.</u>	<u>(Inches)</u>	<u>Remarks</u>
45° SV	15	47			5.9	26 rds. outside 1 3/4" limit 7 rds. below spec. vel.
60° SV	3	6			14.6	3.4
60° DV	9	28			3.4	3 rds. outside 1 3/4" limit 13 rds. outside 1 3/4" limit
90° DV	9	28			4.8	1.0
						8 rds. outside 1 3/4" limit 4 rds. below spec. vel.
<u>Root Gap (Inches)</u>	<u>No. of Plates</u>	<u>No. of Rounds</u>	<u>Av. W. Cr/rd.</u>	<u>Av. Pl. Cr/rd.</u>	<u>(Inches)</u>	<u>Remarks</u>
1/8	4	12			6.5	1.46
5/32	4	14			1.7	1.8
3/16	23	72			5.8	1.0
1/4	5	11			6.5	7.6
						31 rds. outside 1 3/4" limit 11 rds. below spec. vel.
						4 rds. outside 1 3/4" limit

TABLE VI (Cont.)

Joint Design Data for 1/2 Inch Thick Rolled Armor Plates

Backing	No. of Plates	No. of Rounds	Av. Cr/rds.	Av. Pl. Cr/rds.	(Inches)	Remarks
Corner	7	24	3.3	1.5	14 rds. outside 1 3/4" limit	
Brass	18	56	5.4	1.2	24 rds. outside 1 3/4" limit 11 rds. below spec. vel.	
None	11	29	5.1	3.5	12 rds. outside 1 3/4" limit	

Welding Procedure for 1/2 Inch Thick Bolled Armor H Plates

No. of Passes	No. of Plates	No. of Rounds	Average Wt. Cr/rd.	Average Pl. Cr/rd.	Average (Inches)	Remarks
3	7	25	5.8	1.4	12 rds. outside 1 3/4" limit 7 rds. below spec. vel.	
4	7	18	8.9	1.7	8 rds. outside 1 3/4" limit	
6	2	7	1.6	0	4 rds. outside 1 3/4" limit	
8	2	6	7.2	.5	3 rds. outside 1 3/4" limit	
DV	1	3	3.8	0	1 rd. outside 1 3/4" limit	
2	8	25	5.1	1.2	7 rds. outside 1 3/4" limit 3 rds. below spec. vel.	
3	3	11	2.5	0	7 rds. outside 1 3/4" limit	
4	5	11	5.4	6.7	4 rds. outside 1 3/4" limit	
5	1	3	3.3	.7	2 rds. outside 1 3/4" limit	
12						

TABLE VII (Cont.)

Welding Procedure for 1/2 Inch Thick Rolled Armor H Plates

Deposition	No. of Plates	No. of pounds	Average H. Cr/rd.	Average Pl. Cr/rd.	Remarks
		(Inches)	(Inches)	(Inches)	
SV	weaves	14	4.3	7.1	1.5
	single crown				22 rds. outside 1 3/4" limit 7 rds. below spec. vel.
	combination weaves & beads				
	multiple crown	4	13	4.2	0.2
CV	all weaves	17	50	4.7	2.1
					19 rds. outside 1 3/4" limit 3 rds. below spec. vel.
	combination weaves & beads				
	multiple crown	1	3	3.3	3.7
SV	seal bead	9	28	5.1	1.0
	no seal bead	9	28	7.8	1.4
					13 rds. outside 1 3/4" limit 16 rds. outside 1 3/4" limit 7 rds. below spec. vel.

TABLE VII (Cont.)

Welding Procedure for 1/2 Inch Thick Rolled Armor H Plates

Preheat °F	No. of Plates	No. of Rounds	Average		Remarks
			" Cr/rd.	Pl. Cr/rd.	
(Inches)					
70° - 100°	22	64	4.8	2.4	31 rds. outside 1 3/4" limit
250°	14	45	6.2	1.2	19 rds. outside 1 3/4" limit 11 rds. below spec. vel.
			- - - - -	- - - - -	

TABLE VIII

Radiographic Data for 1/2 Inch Thick Rolled Armor I Plates

Radiographic Results	No. of Plates	No. of Rounds	Average		Remarks
			" Cr/rd.	Pl. Cr/rd.	
(Inches)					
Passing	33	100	5.5	1.9	45 rds. outside 1 3/4" limit 11 rds. below spec. vel.
Failing	3	9	4.6	1.8	5 rds. outside 1 3/4" limit

TABLE IX
Fabricators of 3/8 Inch Thick Rolled Armor H Plates

Fabricators	No. of Plates	No. of Rounds	Average w. Cr/rd. (Inches)	Average Fl. Cr/rd. (Inches)	Remarks
Am. Car & Foundry	1	3	2.8	0	1 rd. outside 1 3/16" limit
Buick Motor Div.	2	5	11.7	6.9	1 rd. outside 1 3/4" limit
Chevrolet Motor	36	100	6.5	2.8	37 rds. outside 1 3/16" limit 28 rds. above spec. vel. 3 rds. below spec. vel.
Deere & Co.	2	9	1.0	0.1	5 rds. outside 1 3/4" limit
Ford Motor Co.	15	38	7.3	1.7	14 rds. outside 1 3/4" limit

TABLE X
Armor Data for Hand Welded 3/8 Inch Thick Rolled Armor Plates

Ref.	Type	Chemical Composition	Heat Treatment			BEN	% of Plates Welded	No. of Rds. outside 1 3/4" limit	Remarks
			ct	Ers.	Held				
Z.C. & Ins	VI	.27 C .89 Mn .08 Si .65 Cr .27 Mo .55 Ni	1645 In 1100	1/4 2	Water	321	4	18 1.2	0 11 rds. outside 1 3/4" limit
					Air				
V	High Alloy	.24 - .46 - .19 - 1.42 - .33 - 2.94 -	.29 C .49 Mn .26 Si 1.57 Cr .53 Mo 3.10 Ni	1620 In 1130	1	Air	341- 363	3 6	6.1 0
Chevrolet	IV	.26 - .91 - .71 - .47 - .21 -	.31 C .34 Mn .73 Si .64 Cr .23 Mo	1600 In 855- 1000	1/2 - 4 6	Water Air	311- 352	11 31	6.0 4.3
Forge	III								12 rds. outside 1 3/4" limit 11 rds. above spec. vel. 3 rds. below spec. vel.
Ford	II	.24 - 1.15 - .20 - .50 - .30 -	.30 C 1.43 Mn .30 Si .30 Cr .34 Mo	1650 In 975- 1000	2-4 3-1/4 - 6	Flaten Air	300- 341	15 78	7.3 1.7

TABLE X (Cont.)

Ref.	Type	Chemical Composition	Heat Treatment			No. of Plates	No. of Rds.	Av. Crdg./rd.	Remarks
			c%	hrs.	Hold				
Great Lakes	IV	.26 - .76 - .70 - .47 - .15 -	.29 C .94 Mn .73 Si .59 Cr .23 Mo	1600 15- 1000	1/2 4 Air	311- 341	14 32	8.5 3.7	8 rds. outside 1 3/4" limit 12 rds. above spec. vel.
Jones & Laughlin	III	.27 - 1.60 - .21 - .40 -	.31 C 1.34 Mn .22 Si .46 Ni 1000	1600- 1625 880- 2-	1/2- 1-1/2 4	331- 363	5 13	4.6 6	5 rds. outside 1 3/4" limit 2 rds. above spec. vel.
Republic	VI	.37 - 1.23 -	.39 C .75 Mn .27 Si	1600 1550 850	1 1 3	Air Brine Air	311- 331	11.7 6.9	1 rd. outside 1 3/4" limit
Youngstown	III	.26 C 1.42 Mn .15 Si .24 Mo	1600 750	1/2 4	Water Air	341	2 7	10.4 2.7	3 rds. outside 1 3/4" limit 3 rds. above spec. vel.

TABLE XI
Electrode Data for Hand Welded $\frac{3}{8}$ Inch Thick Rolled Armor H Plates

Mfr.	Brand	Weld Metal Comp.	Coatings	No. Flates	No. Rds.	Average yield cracking per rd. (Inches)		Plate cracking per rd. (Inches)	Remarks
						2	5	11.7	
Alloy Rods	Armorarc 3	.09 - .11 C 2.24 - 3.17 Mn .31 - .41 Si 19.5 - 19.6 Cr 9.4 - 12.5 Ni .06 - .19 Mo .05 - .38 V							1 rd. outside 1 $\frac{3}{4}$ " limit
		.10 - .13 C 1.25 - 1.41 Mn .31 - .38 Si 17.6 - 20.4 Cr 8.9 - 15.7 Ni 2.43 - 3.29 Mo	Titania	8	19	9.2		5.0	6 rds. outside 1 $\frac{3}{4}$ " limit 10 rds. above spec. vel.
Arcos	Caronang	Not Given			3	10	6.2	1.2	4 rds. outside 1 $\frac{3}{4}$ " limit
Crucible	Armorize A	.11 - .14 C 3.58 - 3.95 Mn .31 - .42 Si 19.5 - 19.7 Cr 10.1 - 10.4 Ni 1.17 - 1.18 Mo	Titania	3	6	15.3	3.0	3 rds. above spec. vel. 1 rd. below spec. vel.	

TABLE XI (Cont.)

Mfr.	Brand	Yield Metal Comp.	Coating	No. Plates	No. Rds.	Average Yield cracking per rd. (Inches)	Average Plate cracking per rd. (Inches)	Remarks
		.07 - .11 C	Titania	11	29	5.5	1.3	12 rds. outside 1 3/4" limit
Aerorize		1.82 - 1.96 Mn						
Resistol		.18 - .27 Si						
		18.8 - 20.1 Cr						
		10.0 - 10.2 Ni						
		1.87 - 2.0 Mo						
Harnischfeger	A 3 C	.12 - .15 C	Lime	4	8	8.4	4.3	2 rds. outside 1 3/4" limit
		3.82 - 4.47 Mn						
		.65 - .66 Si						
		19.0 - 19.5 Cr						
		9.5 - 10.3 Ni						
		1.02 - 1.07 Mo						
Rollup	Not Given			1	3	4.2	4.3	1 rd. outside 1 3/4" limit
Lincoln	AEROWELD	Not Given	Lime	1	3	2.4	0	1 rd. outside 1 3/4" limit
McClay	A 5	.08 - .14 C	Lime	5	12	8.4	3.1	5 rds. outside 1 3/4" limit
		3.41 - 3.91 Mn						
		.57 - 1.01 Si						
		19.6 - 19.9 Cr						
		9.3 - 10.8 Ti						
		1.18 - 1.19 Mo						

TABLE XI (Cont.)

Mfr.	Brand	Yield Metal		Coating	No. Plates	No. Rds.	Weld cracking per rd.	Average (Inches)	Plate cracking per rd.	Average (Inches)	Remarks
		Comp.	(Inches)								
AC 5		.12	C	Lime	2	6	.4.6	7.4	3 rds. outside 1 3/4" limit		
		4.41	Mn						4 rds. above spec. vel.		
		.49	Si						1 rd. below spec. vel.		
		13.5	Cr								
		10.0	Ti								
		.75	No								
		.09	-	.12	C	Lime	2	9	1.7	0	6 rds. outside 1 3/4" limit
		4.26	-	4.45	Mn						
		.52	-	.55	Si						
		19.1	-	20.1	Cr						
		5.2	-	9.6	Ti						
Page	Stainless	Not given			1	2	8.4	?	1 rd. outside 1 3/4" limit		

TABLE XII

Joint Design Data for Hand Welded 3/8 Inch Thick Rolled Armor H Plates

Angle of Bevel	No. of Plates	No. of Rounds	Average W. Cr/rd.	Average Pl. Cr/rd.	Average (Inches) (Inches)	Remarks
45° SV	11	29	7.8	2.7	12 rds. outside 1 3/4" limit	
60° SV	8	23	5.2	0.8	8 rds. outside 1 3/4" limit	
60° DV	36	100	6.4	2.8	36 rds. outside 1 3/4" limit 26 rds. above spec. vel. 3 rds. below spec. vel.	
90° DV	1	3	6.2	0	2 rds. outside 1 3/4" limit 2 rds. above spec. vel.	

TABLE XII (Cont.)

Root Gap (Inches)	No. of Plates	No. of Rounds	Average W. Cr/rd. (Inches)	Average Pl. Cr/rd. (Inches)	Remarks
1/8	2	5	8.9	7.3	4 rds. outside 1 3/4" limit
1/8 - 1/4	5	14	6.8	0.3	3 rds. outside 1 3/4" limit
5/32	1	2	11.0	0	1 rd. outside 1 3/4" limit
5/32 - 1/4	1	2	9.6	1.5	
3/16	40	114	6.1	2.4	45 rds. outside 1 3/4" limit 28 rds. above spec. vel. 3 rds. below spec. vel.
1/4	6	15	7.8	2.7	4 rds. outside 1 3/4" limit

TABLE XIII

Welding Procedure for Sand Welded 3/8 Inch Thick Rolled Armor Plates

No. of Fuses Plates	No. of Rounds	Average W. Cr/rd. (Inches)	Average Pl. Cr/rd. (Inches)	Remarks
<u>SINGLE V</u>				
2	1	3	2.8	1 rd. outside 1 3/4" limit
3	12	3.3	2.5	1 1/4 rds. outside 1 3/4" limit
4	6	16	0.5	3 rds. outside 1 3/4" limit
<u>DOUBLE V</u>				
3	14	4.6	0.6	21 rds. outside 1 3/4" limit 3 rds. above spec. vel.
4	1	3	2.8	0
6	22	5.4	4.5	1 1/4 rds. outside 1 3/4" limit 3 rds. below spec. vel. 25 rds. above spec. vel.

TABLE XIII (Cont.)

Deposition	No. of Plates	No. of Rounds	Average W. Cr/rd.	Average Pl. Cr/rd.	Average (Inches)	Remarks
<u>DOUBLE V</u>						
weaves -					22 rds. outside 1 3/4" limit	
single crown	15	49	3.7	0.6	3 rds. above spec. val.	
combination of lead & weave -					1 1/4 rds. outside 1 3/4" limit	
multiple crown	22	54	8.9	4.5	3 rds. below spec. val. 25 rds. above spec. val.	
<u>SINGLE V</u>						
weaves -					1 1/2 rds. outside 1 3/4" limit	
single crown	19	52	6.7	1.9		
Backing	No. of Plates	No. of Rounds	Average W. Cr/rd.	Average Pl. Cr/rd.	Average (Inches)	Remarks
Corner	16	45	6.7	2.1	17 rds. outside 1 3/4" limit	
None	40	110	6.4	2.6	41 rds. outside 1 3/4" limit 28 rds. above spec. val. 3 rds. below spec. val.	

TABLE XIV
Radiographic Data for Hand Welded $\frac{3}{8}$ Inch Thick Rolled Armor E Plates

Radiographic Results	No. of Plates	No. of Rounds	Average % Cr/rd.	Average Fl. Cr/rd.	Remarks
			(Inches)	(Inches)	
Passing	52	141	6.8	2.7	49 rds. outside 1 $\frac{3}{4}$ " limit 27 rds. above spec. vel. 3 rds. below spec. vel.
Failing	4	14	3.6	0	9 rds. outside 1 $\frac{3}{4}$ " limit 1 rd. above spec. vel.

KEY TO TABULATION METHOD AND SYMBOLS

Figure 2 is a sample tabulation of firing record data and gives a key to symbols and method of tabulation. A brief explanation of the items in the tabulation follows:

1. Identification of Test

Information in the first column identifies the test.

2. Armor Data

A. Plate Thickness

Plates in this tabulation are of 1/2, 3/8, and 1/4 inch thick homogeneous armor.

B. Type Armor

The following types of rolled homogeneous armor are used:

R (Rolled)

Typical Analysis

	Type	C	Mn	Si	Cr	Mo	Ni	Zr
I	Mn-Ni-Cr-Mo	.26	1.15	.20	.60	.20	1.00	B added
II	Mn-Cr-Mo	.27	1.30	.25	.55	.42		
III	Mn-Mo	.25	1.60	.22	—	.37		Grainal
IV	Mn-Cr-Mo-Si	.27	.86	.79	.62	.17		.09
V	High Alloy		(Compositions noted in tabulation)					
VI	Special	"	"	"	"			

C. Carbon Content

Carbon content is listed whenever given.

D. Brinell Hardness Number (BHN)

Brinell hardness number on both the front and back of plates is tabulated when given.

E. Process

This refers to the melting practice and is tabulated as open hearth, electric, basic or acid.

F. Heat Treatment

The temperature, time of hold, and type of quench and draw are recorded as given.

3. Electrode Data

These data, often incomplete, are listed as given in each firing record.

A. Type

Since alloys are sometimes added to the coating, electrodes are typed according to the chemical analysis of the weld metal when given.

The electrodes are typed as follows:

(1) Austenitic)

I Mn-Mo Modified 18/8 (Cr-Ni-Fe Alloy)
Weld Analysis - at least 1% Mn and .3% Mo

II Mn Modified 18/8 (Cr-Ni-Fe Alloy)
Weld Analysis - at least 1% Mn and less than .3% Mo

III Mo Modified 18/8 (Cr-Ni-Fe Alloy)
Weld Analysis - at least .3% Mo and less than 1% Mn

IV Special

B. and C. Trade Name and Coating

Trade names and types of coating are listed when given.

D. Current and Polarity

These data are tabulated as DC straight (str.), DC reversed (rev.), or AC.

4. Joint Design

A. Groove, etc.

This item includes the type of groove (Single V bevel or double V bevel), the included angle, and the width of the root face whenever given.

B. Root Gap

This is the distance between the plates as set up for welding.

C. Plate Preparation

This indicates whether the plate edges to be welded together were flame cut, ground, machined, buttered, etc.

5. Welding Procedure

A. Backing

Backing if used, i.e. backup bar, chill, filler and spacer strips, is noted.

B. Deposition

Figure 3 shows how the weld deposition is broken up into the root, body, and crown types. The size electrode is noted with the number of passes, type of passes, and the current and voltage. Passes are divided into two kinds: (1) layer, if the pass bridges the gap; and (2), bead, if the pass does not bridge the gap. Seal beads, when used, are noted with size electrode, current, and voltage.

C. Total Welding Time and Interpass Temperature

These are listed as given.

D. Remarks

Any comments on chipping, grinding, and other special techniques used and not noted above which affect the ballistic results are listed under "remarks."

6. Heat

Preheat and postheat are tabulated when given.

7. Ballistic Results

The type projectile used in testing is specified under the ballistic results. Hits, velocity, and location of each, cracking and remarks on cracking are listed. The types of weld and plate cracking are as follows:

- Type I Cracking in fusion or heat-affected zones on front and back of plate.
- Type II Cracking in fusion or heat-affected zones on one side of plate and weld metal on the other.
- Type III Cracking in weld metal on both front and back of plate.
- Type IV Star plate cracking.
- Type V Linear plate cracks.

The remarks on cracking and results of radiographic examination are recorded in the last column.

SPECIFICATION REQUIREMENTS FOR "H" WELDED PLATES

The following extracts from Specification AXS-497, Rev. 3, describe the present ballistic shock test:

Paragraph II-3a. (2) Shock Tests. The welded plate shown in Fig. 1 shall be tested as shown below. Fig. 1 shows the areas designated for shock impacts. For the purpose of description these are divided in four 'specified areas' one above and one below the crossbar on each of the two vertical leg welds. Aiming points are indicated in Fig. 1.

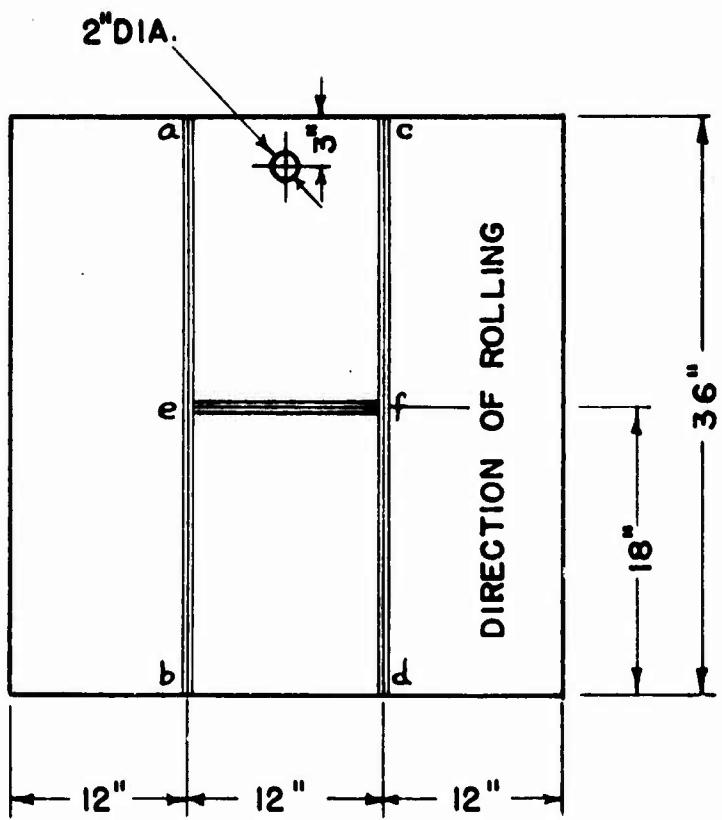
"If the first round falls outside of the one of the four specified areas, another round shall be fired at a second specified area. If the second impact falls outside of the specified area and no cracking occurs in the weld, another round will be fired at a third specified area. This shall be continued until an impact is obtained within one of the four specified areas, but no more than four rounds will be fired at one plate. If the plate withstands all four rounds, all of which fall outside the specified areas, and the weld is not cracked, the plate will be considered acceptable.

BALLISTIC SHOCK TEST*

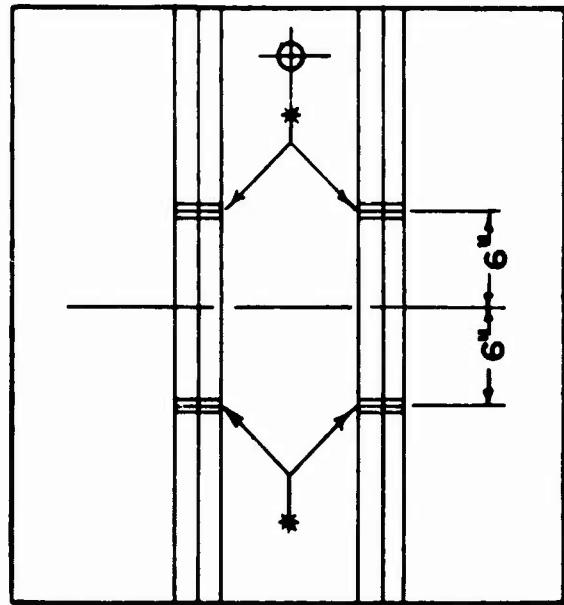
Plate Thick- ness	Type	Projectile	Striking Velocity f/s	Allowable Distance. Center of impact to center of weld	Maximum Cracking Weld	Allowable Plate
1/2"	R.H.	37 mm. H.E. M54	2600	1-3/4"	12"	6"
3/8"	R.H.	37 mm. H.E. M54	2100	1-3/4"	15"	6"
1/4"	R.H.	37 mm. H.E. M54	1700	1-3/4"	—	—
1/4"	R.H.	20 mm.H.E.1 MK.1	1675	1/2"	—	—

* Specifications in a development stage during the period in which plates were tested.

WELD SEQUENCE:
ab, cd, fe.



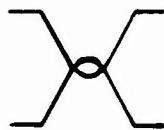
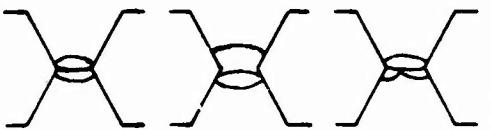
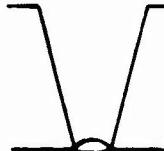
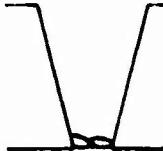
QUALIFICATION SHOCK TEST PLATE

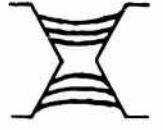


* INTENDED AIMING POINTS

FIG. 1

FIGURE 2. SAMPLE CHART FOR TABULATION OF FIRING RECORD DATA OR WILDERNESS PLATES.

ROOT TYPES	TYPE I	TYPE II
DOUBLE V BEVEL	 SINGLE ROOT BEAD AT CENTER OF ROOT	 MORE THAN ONE BEAD AT ROOT ETC.
SINGLE V BEVEL	 SINGLE BEAD BRIDGING ROOT GAP	 MORE THAN ONE BEAD BRIDGING ROOT GAP ETC.

BODY TYPES	TYPE I	TYPE II	TYPE III	TYPE IV	TYPE V
DOUBLE V BEVEL	 LAYERS ONLY	 BEADS ONLY	 LAYERS & BEADS	UNIONMELT	SPECIAL
SINGLE V BEVEL	 LAYERS ONLY	 BEADS ONLY	 LAYERS & BEADS	UNIONMELT	SPECIAL

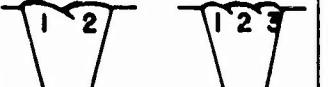
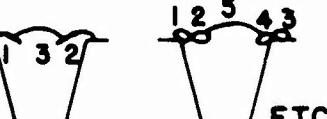
CROWN TYPES	TYPE I	TYPE II	TYPE III
DOUBLE V & SINGLE V BEVEL	 SINGLE CROWN SINGLE PASS BRIDGES GAP	 MULTIPLE CROWN LAST BEAD TOUCHES PARENT METAL	 MULTIPLE CROWN LAST BEAD DOES NOT TOUCH PARENT METAL ETC.

FIG. 3 WELD METAL DEPOSITION TYPES

AD-344		A. 1/2"		A. .41" 1/4"		A. Not given		A. None		A. 1/2"	
B. 3/30/43		B. A-III (.152m-.1381) C-13 D. Youngstown Sheet & Tube Co. Company E. Alloy Rods Co. F. Buick Motor Division		B. A-1 (.110c-.136) C. Mn-.2281, C. GCR, .3380) D. 25 Face 368 Back 368 B. Octo) E. O. N. hr. Water hr. 850°, 1/2 hr. Air		B. 1/2"		B. Flame Cutting		B. 1/2"	
A.	AD-344	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.
A.	AD-344	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.
A.	AD-344	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.

IDENTIFICATION	TEST RECORD NO.	PLATE THICKNESS	ELECTRODE DATA	JOINT DESIGN	WELDING	PROCEDURE	HEAT	BALLOONING	LOCATION OF H.	CRACKING AND	TEST	RADIOPHOTOGRAPHIC RESULT, ETC.
A. 3/4"	B. 3/4"	C. 1/16"	D. 100% 4.3	A. 90°DV	A. Brass	A. 250°	1 2100	3 1/2"	L			
B. 3/4"	C. 3/4"	D. .85Mn-.80Si	E. Mn-.42Si	B. 1/16" 4RF	B. I. 3/16" 1a 140 -	B. None	2 2600	7"	X			
D. Ingersoll		.83Cr-1.2Ni	.20.00Cr	C. Grinding	3. Two layers							
D. Steel Co.		.43Mo	.9-.7Ni)*		1/4" 3a 305 -							
E. McKey Company	C. 30		(.11C-3.94		C. 2:15 hrs. 2400 - 2500°F.		3 2600	1 1/2"	U	Imp	II	3 1/2"
F. Marmon-Herr-	D. Face 363		Mn-.47Si		D. Chipping after first pass.		4 2600	X				
ingtonCo. Inc.	Back 388		.20.5Cr									
F. 1600°F.	B. Elec.		10.05Ni)*									
F. 900°F.	40		B. Armorloy									
F. Draw			A-5									
A. AD-285	A. 1/2"	A. A-II	A. 90°DV	A. Brass	A. 250°	1 2600	X	5 1/2"	R	Imp	I	3"
B. 3/4"	C. H.H. V	D. (.10C-4.20	E. Mn-.42Si	F. 1/16" 4RF	G. I. 3/16" 1a 145 -	B. None	3 2600	2 1/2"	R	Imp	III	1 1/2"
C. EW-4324		.95Mn-.87Si	.20.8Cr	C. Grinding	3. Two layers					V		
D. Ingersoll		.98Cr-1.2Ni	.9-.7Ni)*		1/4" 2a 205 -							
D. Steel Co.		.44Mo)	(.11C-3.94		C. 3 hrs. 250° - 280°F.							
E. McKey Company	C. 30		Mn-.47Si		D. Cracking and chipping		3 2600	3 1/2"	L			
F. Marmon-Herr-	D. Face 363		.20.5Cr		after first pass.		4 2600	1 1/2"	R	O	V	5 1/2"
ingtonCo. Inc.	Back 388		10.05Ni)*									
F. 1600°F.	B. Elec.		B. Armorloy									
F. 900°F.	40		A-5									
F. Draw			D. DC REV									
A. AD-285	A. 1/2"	A. A-II	A. 90°DV	A. Brass	A. 250°	1 2600	X	5 1/2"	R	Imp	I	3 1/2" projectile
B. 3/4"	C. H.H. V	D. (.10C-4.20	E. Mn-.42Si	F. 1/16" 4RF	G. I. 3/16" 1a 145 -	B. None	3 2600	2 1/2"	R	Imp	III	1 1/2" projectile
C. EW-4325		.95Mn-.87Si	.20.8Cr	C. Grinding	3. Two layers					V		
D. Ingersoll		.98Cr-1.2Ni	.9-.7Ni)*		1/4" 2a 205 -							
D. Steel Co.		.44Mo)	(.11C-3.94		C. 3 hrs. 250° - 280°F.							
E. McKey Company	C. 30		Mn-.47Si		D. Cracking and chipping		3 2600	3 1/2"	L			
F. Marmon-Herr-	D. Face 363		.20.5Cr		after first pass.		4 2600	1 1/2"	R	O	V	5 1/2"
ingtonCo. Inc.	Back 388		10.05Ni)*									
F. 1600°F.	B. Elec.		B. Armorloy									
F. 900°F.	40		A-5									
F. Draw			D. DC REV									
A. AD-345	A. 1/2"	A. A-II	A. 90°DV	A. Brass	A. 250°	1 2600	2"	6 1/2"	R	Imp	II	3"
B. 3/24/43	B. H.H. IV	C. .91Mn-.79Si	D. Mn-.46Si	E. 1/16" 4RF	F. I. 3/16" 1a 145 -	B. None	2 2600	X	11"	Imp	I	6 1/2"
C. EW-4333		.64Cr-.21Mo	.20.00Cr	C. Grinding	3. Two layers					U	Imp	II
D. Great Lakes		C. .28	10.00Ni)*		1/4" 3a 205 -							
D. Steel Cor.		D. Face 364	(.11C-3.94		C. 3 hrs. 250°F.							
E. McKey Company	D. Back 364		Mn-.47Si		D. Cracking and chipping		3 2600	1 1/2"	L			
F. Marmon-Herr-	E. B.O.H.		.20.5Cr		after all passes.							
ingtonCo. Inc.	F. 1650°F.		10.05Ni)*									
F. 950°F.	40		B. Armorloy									
F. Draw			A-5									
F. Draw			D. DC REV									

*Weld Metal

TESTS ON DRILLING AND CUTTING OF PLATE MATERIAL													
TEST NO.	PLATE TESTED	TEST TYPE	TEST NUMBER	TEST DESCRIPTION	TEST CONDITIONS	TEST DATA	TESTS	TESTS	TESTS	TESTS	TESTS		
							A. VOLTAGE	B. CURRENT	C. TIME	D. TEMPERATURE	K. PLATE THICKNESS		
A. AD-345 B. 3/26/43 C. SW-4334 D. Great Lakes Steel Corp. E. McKay Company F. Morrison-Herrington Co. Inc. G. B.O.H. H. Water I. Draw	A. 1/8" B. H.H. IV (.918M-.7981) C. 50Cr-21Mo. D. .38 E. Pace 351 F. Back 351 G. B.O.H. H. Water I. Draw	A. A-II (.110C 3.78 1.16" RF 19.3Cr. 10.1M.) C. Grinding D. Pace 351 E. B.O.H. F. Water G. Draw	A. 450SV 1/16" RF 3/16" C. Grinding C. Grinding D. Pace 351 E. B.O.H. F. Water G. Draw	A. Brass B. C. D. E. F. G. H. I. J. K.	B. None B. None	A. 350° F. B. None C. 350° F. D. 350° F. E. 350° F. F. 350° F. G. 350° F. H. 350° F. I. 350° F. J. 350° F. K. 350° F.	1 2600 2 2600 3 2600 4 2600 5 2600 6 2600 7 2600 8 2600 9 2600 10 2600 11 2600	1" L 1" R 1" U 1" D 1" L 1" R 1" U 1" L 1" R 1" U 1" D	1" 9" Imp 1" 9" Imp	1 11 2 11 3 11 4 11 5 11 6 11 7 11 8 11 9 11 10 11 11 11	1 11 2 11 3 11 4 11 5 11 6 11 7 11 8 11 9 11 10 11 11 11	1 11 2 11 3 11 4 11 5 11 6 11 7 11 8 11 9 11 10 11 11 11	1 11 2 11 3 11 4 11 5 11 6 11 7 11 8 11 9 11 10 11 11 11
A. AD-341 B. 3/26/43 C. SW-4336 D. Great Lakes Steel Corp. E. McKay Company F. Morrison-Herrington Co. Inc. G. B.O.H. H. Water I. Draw	A. 1/2" B. H.H. IV (.970M-.7531) C. 50Cr-21Mo. D. .28 E. Pace 363 F. Back 375 G. B.O.H. H. Water I. Draw	A. A-II (.110C 3.79 1.16" RF 19.3Cr. 10.25M.) C. Grinding D. Pace 363 E. B.O.H. F. Water G. Draw	A. 500SV 1/16" RF 3/16" C. Grinding C. Grinding D. Pace 363 E. B.O.H. F. Water G. Draw	A. Brass B. C. D. E. F. G. H. I. J. K.	B. None B. None	A. 350° F. B. None C. 350° F. D. 350° F. E. 350° F. F. 350° F. G. 350° F. H. 350° F. I. 350° F. J. 350° F. K. 350° F.	1 2600 2 2600 3 2600 4 2600 5 2600 6 2600 7 2600 8 2600 9 2600 10 2600 11 2600	1" L 1" R 1" D 1" L 1" D 1" L 1" D 1" L 1" D 1" L 1" D	1" 9" Imp 1" 9" Imp	1 11 2 11 3 11 4 11 5 11 6 11 7 11 8 11 9 11 10 11 11 11	1 11 2 11 3 11 4 11 5 11 6 11 7 11 8 11 9 11 10 11 11 11	1 11 2 11 3 11 4 11 5 11 6 11 7 11 8 11 9 11 10 11 11 11	
A. AD-341 B. 3/26/43 C. SW-4338 D. Great Lakes Steel Corp. E. McKay Company F. Morrison-Herrington Co. Inc.	A. 1/2" B. H.H. IV (.970M-.7531) C. 53Cr-24Mo. D. .28 E. Pace 363 F. Back 375 G. B.O.H. H. Water I. Draw	A. A-II (.110C 3.79 1.16" RF 19.85Cr. 10.21M.) C. Grinding D. Pace 363 E. B.O.H. F. Water G. Draw	A. 500SV 1/16" RF 3/16" C. Grinding C. Grinding D. Pace 363 E. B.O.H. F. Water G. Draw	A. Brass B. C. D. E. F. G. H. I. J. K.	B. None B. None	A. 350° F. B. None C. 350° F. D. 350° F. E. 350° F. F. 350° F. G. 350° F. H. 350° F. I. 350° F. J. 350° F. K. 350° F.	1 2600 2 2600 3 2600 4 2600 5 2600 6 2600 7 2600 8 2600 9 2600 10 2600 11 2600	1" L 1" R 1" D 1" L 1" D 1" L 1" D 1" L 1" D 1" L 1" D	1" 9" Imp 1" 9" Imp	1 11 2 11 3 11 4 11 5 11 6 11 7 11 8 11 9 11 10 11 11 11	1 11 2 11 3 11 4 11 5 11 6 11 7 11 8 11 9 11 10 11 11 11	1 11 2 11 3 11 4 11 5 11 6 11 7 11 8 11 9 11 10 11 11 11	
A. AD-341 B. 3/26/43 C. SW-4338 D. Great Lakes Steel Corp. E. McKay Company F. Morrison-Herrington Co. Inc.	A. 1/2" B. H.H. IV (.970M-.7531) C. 53Cr-24Mo. D. .28 E. Pace 363 F. Back 375 G. B.O.H. H. Water I. Draw	A. A-II (.110C 3.79 1.16" RF 19.85Cr. 10.21M.) C. Grinding D. Pace 363 E. B.O.H. F. Water G. Draw	A. 500SV 1/16" RF 3/16" C. Grinding C. Grinding D. Pace 363 E. B.O.H. F. Water G. Draw	A. Brass B. C. D. E. F. G. H. I. J. K.	B. None B. None	A. 350° F. B. None C. 350° F. D. 350° F. E. 350° F. F. 350° F. G. 350° F. H. 350° F. I. 350° F. J. 350° F. K. 350° F.	1 2600 2 2600 3 2600 4 2600 5 2600 6 2600 7 2600 8 2600 9 2600 10 2600 11 2600	1" L 1" R 1" D 1" L 1" D 1" L 1" D 1" L 1" D 1" L 1" D	1" 9" Imp 1" 9" Imp	1 11 2 11 3 11 4 11 5 11 6 11 7 11 8 11 9 11 10 11 11 11	1 11 2 11 3 11 4 11 5 11 6 11 7 11 8 11 9 11 10 11 11 11	1 11 2 11 3 11 4 11 5 11 6 11 7 11 8 11 9 11 10 11 11 11	

13

Weld Metal

TEST INFORMATION	TESTING SITE	PLATE THICKNESS	ELECTRICAL DATA	JOINT DESIGN	WELDING	PROCEDURE	HEAT	BALLISTICS		LOCATION OF A CHARGED PROJECTILE AND TYPE	RANGE IN FEET	TIME OF CONDUCTING TEST	
								A. TYPE	B. NAME	C. GROOVE	D. BACKING	E. PLATE NAME	F. PLATE THICKNESS
A. AD-46	B. 10/1/42	C. 3/8"	D. R-IV	A. 4-I	A. 60°DV	A. Not given	A. None	1 2300	5 1/2"	L	O	II	31"
B.	C.	(.91Mn-.71Si)	(.59Cr-.23Mo)	(.13C(.4-.41)	1/16" RF	B. 1. I 1/8"	B. None		1/8"	D	V	III	83"
D.	E.	Mn-.31Si1,	20-40R,	Mn-.49Si1,	3/16"	2. & Five beads			5/32"			III	83"
F.	G.	.28	13-.781,	18-5CR,	C. Machining	3. 5/32"			1/8"			III	83"
H.	I.	3-29Mo)*	3-29Mo)	10.0Ni1,		4. 1/8"			1/8"			III	83"
J.	K.	Face 331	Back 331	Face 331		5. 1/8"			1/8"			III	83"
L.	M.	3. Arcoara	3. Arcoara	3. Arcoara		6. 1/8"			1/8"			III	83"
N.	O.	B-0-H.	B-0-H.	B-0-H.		7. 100°F.			1/8"			III	83"
P.	Q.	1600°F.	1600°F.	1600°F.		8. 1600°F.			1/8"			III	83"
R.	S.	Water	Water	Water		9. 1600°F.			1/8"			III	83"
T.	U.	9150F. 6 hrs.	9150F. 6 hrs.	9150F. 6 hrs.		10. 1600°F.			1/8"			III	83"
V.	W.	Air	Air	Air		11. 1600°F.			1/8"			III	83"
X.	Y.	Z.	Z.	Z.		12. 1600°F.			1/8"			III	83"
A. AD-46	B. 10/1/42	C. 3/8"	D. R-IV	A. 4-I	A. 60°DV	A. Not given	A. None	1 2000	1 1/2"	L	4"	Passed radiograph	
B.	C.	(.91Mn-.71Si1)	(.59Cr-.23Mo)	(.13C(.4-.41)	1/16" RF	B. 1. I 1/8"	B. None		1/8"	D			
D.	E.	Mn-.31Si1,	20-40R,	Mn-.49Si1,	3/16"	2. & Five beads			5/32"				
F.	G.	.28	13-.781,	18-5CR,	C. Machining	3. 5/32"			1/8"				
H.	I.	3-29Mo)*	3-29Mo)	10.0Ni1,		4. 1/8"			1/8"				
J.	K.	Face 331	Back 331	Face 331		5. 1/8"			1/8"				
L.	M.	B-0-H.	B-0-H.	B-0-H.		6. 1/8"			1/8"				
N.	O.	AC-5	AC-5	AC-5		7. 1/8"			1/8"				
P.	Q.	Line	Line	Line		8. 1/8"			1/8"				
R.	S.	D. DC REV	D. DC REV	D. DC REV		9. 1/8"			1/8"				
T.	U.	Water	Water	Water		10. 1/8"			1/8"				
V.	W.	9150F. 6 hrs.	9150F. 6 hrs.	9150F. 6 hrs.		11. 1/8"			1/8"				
X.	Y.	Z.	Z.	Z.		12. 1/8"			1/8"				
A. AD-46	B. 10/1/42	C. 3/8"	D. R-IV	A. 4-I	A. 60°DV	A. Not given	A. None	1 2000	3"	R	84"	Passed radiograph	
B.	C.	(.94Mn-.73Si1)	(.47Cr-.23Mo)	(.12C(.3-.82)	1/16" RF	B. 1. I 1/8"	B. None		1/8"	D			
D.	E.	Mn-.66Si1,	19.00Cr,	Mn-.66Si1,	3/16"	2. & Five beads			5/32"				
F.	G.	.29	10.3Ni1,	10.3Ni1,	C. Machining	3. 5/32"			1/8"				
H.	I.	1.02Mo)*	1.02Mo)*	1.02Mo)*		4. 1/8"			1/8"				
J.	K.	Face 321	Back 321	Face 321		5. 1/8"			1/8"				
L.	M.	B-0-H.	B-0-H.	B-0-H.		6. 1/8"			1/8"				
N.	O.	1600°F.	1600°F.	1600°F.		7. 1/3 hrs.			1/8"				
P.	Q.	Water	Water	Water		8. 1/3 hrs.			1/8"				
R.	S.	9150F. 6 hrs.	9150F. 6 hrs.	9150F. 6 hrs.		9. 1/3 hrs.			1/8"				
T.	U.	Air	Air	Air		10. 1/3 hrs.			1/8"				
V.	W.	Z.	Z.	Z.		11. 1/3 hrs.			1/8"				
X.	Y.	Z.	Z.	Z.		12. 1/3 hrs.			1/8"				
A. AD-46	B. 10/1/42	C. 3/8"	D. R-IV	A. 4-I	A. 60°DV	A. Not given	A. None	1 2300	1 1/2"	L	64"	Passed radiograph	
B.	C.	(.94Mn-.73Si1)	(.47Cr-.23Mo)	(.12C(.3-.82)	1/16" RF	B. 1. I 1/8"	B. None		1/8"	D			
D.	E.	Mn-.66Si1,	19.00Cr,	Mn-.66Si1,	3/16"	2. & Five beads			5/32"				
F.	G.	.29	10.3Ni1,	10.3Ni1,	C. Machining	3. 5/32"			1/8"				
H.	I.	1.02Mo)*	1.02Mo)*	1.02Mo)*		4. 1/8"			1/8"				
J.	K.	Face 321	Back 321	Face 321		5. 1/8"			1/8"				
L.	M.	B-0-H.	B-0-H.	B-0-H.		6. 1/8"			1/8"				
N.	O.	1600°F.	1600°F.	1600°F.		7. 1/3 hrs.			1/8"				
P.	Q.	Water	Water	Water		8. 1/3 hrs.			1/8"				
R.	S.	9150F. 6 hrs.	9150F. 6 hrs.	9150F. 6 hrs.		9. 1/3 hrs.			1/8"				
T.	U.	Air	Air	Air		10. 1/3 hrs.			1/8"				
V.	W.	Z.	Z.	Z.		11. 1/3 hrs.			1/8"				
X.	Y.	Z.	Z.	Z.		12. 1/3 hrs.			1/8"				
A. AD-46	B. 10/1/42	C. 3/8"	D. R-IV	A. 4-I	A. 60°DV	A. Not given	A. None	1 2000	3"	R	84"	Passed radiograph	
B.	C.	(.94Mn-.73Si1)	(.47Cr-.23Mo)	(.12C(.3-.82)	1/16" RF	B. 1. I 1/8"	B. None		1/8"	D			
D.	E.	Mn-.66Si1,	19.00Cr,	Mn-.66Si1,	3/16"	2. & Five beads			5/32"				
F.	G.	.29	10.3Ni1,	10.3Ni1,	C. Machining	3. 5/32"			1/8"				
H.	I.	1.02Mo)*	1.02Mo)*	1.02Mo)*		4. 1/8"			1/8"				
J.	K.	Face 321	Back 321	Face 321		5. 1/8"			1/8"				
L.	M.	B-0-H.	B-0-H.	B-0-H.		6. 1/8"			1/8"				
N.	O.	1600°F.	1600°F.	1600°F.		7. 1/3 hrs.			1/8"				
P.	Q.	Water	Water	Water		8. 1/3 hrs.			1/8"				
R.	S.	9150F. 6 hrs.	9150F. 6 hrs.	9150F. 6 hrs.		9. 1/3 hrs.			1/8"				
T.	U.	Air	Air	Air		10. 1/3 hrs.			1/8"				
V.	W.	Z.	Z.	Z.		11. 1/3 hrs.			1/8"				
X.	Y.	Z.	Z.	Z.		12. 1/3 hrs.			1/8"				
A. AD-46	B. 10/1/42	C. 3/8"	D. R-IV	A. 4-I	A. 60°DV	A. Not given	A. None	1 2300	1 1/2"	L	64"	Passed radiograph	
B.	C.	(.94Mn-.73Si1)	(.47Cr-.23Mo)	(.12C(.3-.82)	1/16" RF	B. 1. I 1/8"	B. None		1/8"	D			
D.	E.	Mn-.66Si1,	19.00Cr,	Mn-.66Si1,	3/16"	2. & Five beads			5/32"				
F.	G.	.29	10.3Ni1,	10.3Ni1,	C. Machining	3. 5/32"			1/8"				
H.	I.	1.02Mo)*	1.02Mo)*	1.02Mo)*		4. 1/8"			1/8"				
J.	K.	Face 321	Back 321	Face 321		5. 1/8"			1/8"				
L.	M.	B-0-H.	B-0-H.	B-0-H.		6. 1/8"			1/8"				
N.	O.	1600°F.	1600°F.	1600°F.		7. 1/3 hrs.			1/8"				
P.	Q.	Water	Water	Water		8. 1/3 hrs.			1/8"				
R.	S.	9150F. 6 hrs.	9150F. 6 hrs.	9150F. 6 hrs.		9. 1/3 hrs.			1/8"				
T.	U.	Air	Air	Air		10. 1/3 hrs.			1/8"				
V.	W.	Z.	Z.	Z.		11. 1/3 hrs.			1/8"				
X.	Y.	Z.	Z.	Z.		12. 1/3 hrs.			1/8"				
A. AD-46	B. 10/1/42	C. 3/8"	D. R-IV	A. 4-I	A. 60°DV	A. Not given	A. None	1 2000	3"	R	84"	Passed radiograph	
B.	C.	(.94Mn-.73Si1)	(.47Cr-.23Mo)	(.12C(.3-.82)	1/16" RF	B. 1. I 1/8"	B. None		1/8"	D			
D.	E.	Mn-.66Si1,	19.00Cr,	Mn-.66Si1,	3/16"	2. & Five beads			5/32"				
F.	G.	.29	10.3Ni1,	10.3Ni1,	C. Machining	3. 5/32"			1/8"				
H.	I.	1.02Mo)*	1.02Mo)*	1.02Mo)*		4. 1/8"			1/8"				
J.	K.	Face 321	Back 321	Face 321		5. 1/8"			1/8"				
L.	M.	B-0-H.	B-0-H.	B-0-H.		6. 1/8"			1/8"				
N.	O.	1600°F.	1600°F.	1600°F.		7. 1/3 hrs.			1/8"				
P.	Q.	Water	Water	Water		8. 1/3 hrs.			1/8"				
R.	S.	9150F. 6 hrs.	9150F. 6 hrs.	9150F. 6 hrs.		9. 1/3 hrs.			1/8"				
T.	U.	Air	Air	Air		10. 1/3 hrs.			1/8"				
V.	W.	Z.	Z.	Z.		11. 1/3 hrs.			1/8"				
X.	Y.	Z.	Z.	Z.		12. 1/3 hrs.			1/8"				
A. AD-46	B. 10/1/42	C. 3/8"	D. R-IV	A. 4-I	A. 60°DV	A. Not given	A. None	1 2300	1 1/2"	L	64"	Passed radiograph	
B.	C.	(.94Mn-.73Si1)	(.47Cr-.23Mo)	(.12C(.3-.82)	1/16" RF	B. 1. I 1/8"	B. None		1/8"	D			
D.	E.	Mn-.66Si1,	19.00Cr,	Mn-.66Si1,	3/16"	2. & Five beads			5/32"				
F.	G.	.29	10.3Ni1,	10.3Ni1,	C. Machining	3. 5/32"			1/8"				
H.	I.	1.02Mo)*	1.02Mo)*	1.02Mo)*		4. 1/8"			1/8"				
J.	K.	Face 321	Back 321	Face 321		5. 1/8"			1/8"				
L.	M.	B-0-H.	B-0-H.	B-0-H.		6. 1/8"			1/8"				
N.	O.	1600°F.	1600°F.	1600°F.		7. 1/3 hrs.			1/8"				
P.	Q.	Water	Water	Water		8. 1/3 hrs.			1/8"				
R.	S.	9150F. 6 hrs.	9150F. 6 hrs.	9150F. 6 hrs.		9. 1/3 hrs.			1/8"				
T.	U.	Air	Air	Air		10. 1/3 hrs.			1/8"				
V.	W.	Z.	Z.	Z.		11. 1/3 hrs.			1/8"				
X.	Y.	Z.	Z.	Z.		12. 1/3 hrs.			1/8"				
A. AD-46	B. 10/1/42	C. 3/8"	D. R-IV	A. 4-I	A. 60°DV	A. Not given	A. None	1 2000	3"	R	84"	Passed radiograph	
B.	C.	(.94Mn-.73Si1)	(.47Cr-.23Mo)	(.12C(.3-.82)	1/16" RF	B. 1. I 1/8"	B. None		1/8"	D			
D.	E.	Mn-.66Si1,	19.00Cr,	Mn-.66Si1,	3/16"	2. & Five beads			5/32"				
F.	G.	.29	10.3Ni1,	10.3Ni1,	C. Machining	3. 5/32"			1/8"				
H.	I.	1.02Mo)*											

TESTED ON COMING MANUFACTURED IN U.S.A.										
TESTED ON		TESTED ON		TESTED ON		TESTED ON		TESTED ON		
A. PLATE TESTED ON	B. PLATE TESTED ON	A. PLATE TESTED ON	B. PLATE TESTED ON	A. PLATE TESTED ON	B. PLATE TESTED ON	A. PLATE TESTED ON	B. PLATE TESTED ON	A. PLATE TESTED ON	B. PLATE TESTED ON	
A. AD-60 B. 10/15/42 C. KW-125-F D. Chevrolet E. Alloy Rods Co. F. Chevrolet Motor Co.	A. 3/8" B. R-IV (.94Mn-.73Mo) C. .29 D. Face 321 E. B.O.H. F. 1600°F., 35 mins. Water 990°F., 4 hrs. Air	A. 600DV A-I (.13C 1.41 Mn-.31Si) B. 3/16" NF C. Machining 13.7Ni (3.29Mo)* (1.0C 1.25 Mn-.38Si, 17.6Cr, 8.9Ni, 2.3Mo)* B. Armorarc C. T10 D. DC REV	A. Not Given B. 1/16" NF Mn-.31Si 20.4Cr, 13.7Ni Face 321 Back 321 E. B.O.H. F. 1600°F., 35 mins. Water 990°F., 4 hrs. Air	A. None B. None	A. 600DV A-I (.13C 1.41 Mn-.31Si) B. 3/16" NF C. Machining 13.7Ni (3.29Mo)* (1.0C 1.25 Mn-.38Si, 17.6Cr, 8.9Ni, 2.3Mo)* B. Armorarc C. T10 D. DC REV	A. Not Given B. 1/16" NF Mn-.31Si 20.4Cr, 13.7Ni Face 321 Back 321 E. B.O.H. F. 1600°F., 35 mins. Water 990°F., 4 hrs. Air	A. None B. None	A. 600DV A-I (.13C 1.41 Mn-.31Si) B. 3/16" NF C. Machining 13.7Ni (3.29Mo)* (1.0C 1.25 Mn-.38Si, 17.6Cr, 8.9Ni, 2.3Mo)* B. Armorarc C. T10 D. DC REV	A. Not Given B. 1/16" NF Mn-.31Si 20.4Cr, 13.7Ni Face 321 Back 321 E. B.O.H. F. 1600°F., 35 mins. Water 990°F., 4 hrs. Air	A. Not Given B. 1/16" NF Mn-.31Si 20.4Cr, 13.7Ni Face 321 Back 321 E. B.O.H. F. 1600°F., 35 mins. Water 990°F., 4 hrs. Air
A. AD-60 B. 10/15/42 C. KW-127-F D. Chevrolet E. Alloy Rods Co. F. Chevrolet Motor Co.	A. 3/8" B. R-IV (.91Mn-.73Mo) C. .28 D. Face 311 E. B.O.H. F. 1600°F., 35 mins. Water 990°F., 4 hrs. Air	A. 600DV A-I (.13C 1.41 Mn-.31Si) B. 3/16" NF C. Machining 13.7Ni (3.29Mo)* (1.0C 1.25 Mn-.38Si, 17.6Cr, 8.9Ni, 2.3Mo)* B. Armorarc C. T10 D. DC REV	A. Not Given B. 1/16" NF Mn-.31Si 20.4Cr, 13.7Ni Face 311 Back 311 E. B.O.H. F. 1600°F., 35 mins. Water 990°F., 4 hrs. Air	A. None B. None	A. 600DV A-I (.13C 1.41 Mn-.31Si) B. 3/16" NF C. Machining 13.7Ni (3.29Mo)* (1.0C 1.25 Mn-.38Si, 17.6Cr, 8.9Ni, 2.3Mo)* B. Armorarc C. T10 D. DC REV	A. Not Given B. 1/16" NF Mn-.31Si 20.4Cr, 13.7Ni Face 311 Back 311 E. B.O.H. F. 1600°F., 35 mins. Water 990°F., 4 hrs. Air	A. None B. None	A. 600DV A-I (.13C 1.41 Mn-.31Si) B. 3/16" NF C. Machining 13.7Ni (3.29Mo)* (1.0C 1.25 Mn-.38Si, 17.6Cr, 8.9Ni, 2.3Mo)* B. Armorarc C. T10 D. DC REV	A. Not Given B. 1/16" NF Mn-.31Si 20.4Cr, 13.7Ni Face 311 Back 311 E. B.O.H. F. 1600°F., 35 mins. Water 990°F., 4 hrs. Air	A. Not Given B. 1/16" NF Mn-.31Si 20.4Cr, 13.7Ni Face 311 Back 311 E. B.O.H. F. 1600°F., 35 mins. Water 990°F., 4 hrs. Air
A. AD-60 B. 10/15/42 C. KW-128-F D. Chevrolet E. Alloy Corp. F. Chevrolet Motor Co.	A. 3/8" B. R-IV (.91Mn-.73Mo) C. .28 D. Face 311 E. B.O.H. F. 1600°F., 35 mins. Water 990°F., 4 hrs. Air	A. 600DV A-I (.13C 4.41 Mn-.49Si, 10.0Ni, .75Mo)* A-II (.13C 4.26 Mn-.52Si, 19.1Cr, 9.4Ni)* AC-5 C. Lime D. DC REV	A. Not Given B. 1/16" NF Mn-.49Si, 10.0Ni, .75Mo)* A-II (.13C 4.26 Mn-.52Si, 19.1Cr, 9.4Ni)* AC-5 C. Lime D. DC REV	A. None B. None	A. 600DV A-I (.13C 4.41 Mn-.49Si, 10.0Ni, .75Mo)* A-II (.13C 4.26 Mn-.52Si, 19.1Cr, 9.4Ni)* AC-5 C. Lime D. DC REV	A. Not Given B. 1/16" NF Mn-.49Si, 10.0Ni, .75Mo)* A-II (.13C 4.26 Mn-.52Si, 19.1Cr, 9.4Ni)* AC-5 C. Lime D. DC REV	A. None B. None	A. 600DV A-I (.13C 4.41 Mn-.49Si, 10.0Ni, .75Mo)* A-II (.13C 4.26 Mn-.52Si, 19.1Cr, 9.4Ni)* AC-5 C. Lime D. DC REV	A. Not Given B. 1/16" NF Mn-.49Si, 10.0Ni, .75Mo)* A-II (.13C 4.26 Mn-.52Si, 19.1Cr, 9.4Ni)* AC-5 C. Lime D. DC REV	A. Not Given B. 1/16" NF Mn-.49Si, 10.0Ni, .75Mo)* A-II (.13C 4.26 Mn-.52Si, 19.1Cr, 9.4Ni)* AC-5 C. Lime D. DC REV

TESTS ON CARBON STEEL PLATES AND PROJECTILES											
TEST NUMBER	PLATE SOURCE	PLATE SIZE	TEST NUMBER	TEST NAME	TESTED	TESTED	TESTED	TESTED	TESTED	TESTED	TESTED
					A. PLATE NO.	B. DATE OF TEST	C. TYPE	D. IRON CONTENT	E. GRAIN	F. PLATE TREATMENT	G. PLATE SURFACE
A. AD-132 B. 13/2/42 C. XW-171-F D. Great Lakes Steel Corp. E. McKay Company F. Chevrolet Motor Co.	A. 3/8" B. R-IV (.91Mn-.71Si) .59Cr-.23Mo C. .28 D. Face 341 Back 341 E. B.O.H. F. 1600°F. 35 1000°F. 4 hrs. Air	A. A-II B. R-IV (.13C 4.26 Mn..56Si, B. 1/4 1.91Cr, 9.4N1)* C. Grinding	A. 600°F 1/16" RF B. Not Given 1. I 5/32" 2.4 3. Two layers 1/4" C. 7 hrs. 20.1Cr Mn..56Si, 9.6N1)* D. Peening - first pass	A. None B. None	1. 2100 2. 2100 3. 2100 3. 2100	X 1a 1a 1a 1a	1. 2100 2. 2100 3. 2100 3. 2100	4" D 4" U 3 1/2" R 3 1/2" R	Imp III O D	6" Imp 5" Large amount of incomplete weld fusion 6" Passed radiograph Large amount of incomplete weld fusion	
A. AD-132 B. 13/2/42 C. XW-171-F D. Great Lakes Steel Corp. E. Alloy Rods Co. F. Chevrolet Motor Co.	A. 3/8" B. R-IV (.91Mn-.71Si) .59Cr-.23Mo C. .28 D. Face 341 Back 341 E. B.O.H. F. 1600°F. 35 1000°F. 4 hrs. Air	A. A-I B. R-IV (.10C 1.25 Mn..38Si, B. 1/4 1.76Cr, 6.9N1)* C. Grinding D. Face 341 Back 341 E. B.O.H. F. 1600°F. 35 1000°F. 4 hrs. Air	A. 600°F 1/16" RF B. Not Given 1. I 5/32" 2.4 3. Two layers 1/4" C. 8 hrs. 20.1Cr Mn..26Si, 18.6Cr, 9.6N1)* D. Peening - first pass	A. None B. None	1. 2100 2. 2100 3. 2100 3. 2100	X 1a 1a 1a	1. 2100 2. 2100 3. 2100 3. 2100	6" A 5" D 6" U 1" L	Imp Imp Imp 1" 9" 1" 5"	Passed radiograph 1" crater crack near right weld Junction Failed radiograph Excessive amount of incomplete fusion	
A. AD-201 B. 1/16/43 C. XW-173-F D. E.C. Atkins Corp. E. Harnischfeger Corp. F. Chevrolet Motor Co.	A. 3/8" B. R-V (.89Mn,.98Si, .65Cr(.55Ni, .27Mo)* C. .27 D. Face 321 Back 321 E. B. Elec. F. 1645°F. mins. Water 1100°F. 2 hrs. Air	A. A-I B. R-V (.115C 4.47 Mn..65Si, 1.9.5Cr, 9.5N1)* C. Grinding D. Face 321 Back 321 E. B. Elec. F. 1645°F. mins. Water 1100°F. 2 hrs. Air	A. 600°F 1/16" RF B. Not Given 1. I 5/32" 2.4 3. Two layers 1/4" C. 5-1/2 hrs. 20.1Cr Mn..47Si, 19.00Cr, 10.7Ni)* D. Peening - first pass	A. None B. None	1. 2100 2. 2100 3. 2100 4. 2100	X 1a 1a 1a	4" L 4" R 3 1/2" L X	6" U 6" D 3 1/2" U 4" D	Passed radiograph AW-3-C projectile		
											*Weld Metal

27

TEST NUMBER	TESTING DATA	TESTING DATA	TEST DESIGN	WELDING	PROCEDURE	BALLOON SIGHTS		GRAPHIC		REPORTING PERIOD
						A. SMOOTH B. TYPE C. CARBON CONTENT D. BURN E. PROCESS F. HEAT TREATMENT	A. SMOOTH B. TYPE NAME C. GATING D. CURRENT & POLARITY	B. DEPORATION SIZE EL. NO. TYPE AIR	C. PLATE PREPARATION	
RESULTS ON CRUCIBLE STEEL TESTS										
A. AD-201 B. 1/16/43 C. KW-174-F D. F.C. Atkins McLay Company E. Chevrolet Motor Co.	A. 3/8" B. R-V (.89Mn, .98Si, .65Cr, .55Ni, .27Mo) C. .27 D. Face 321 Back 321 E. --- F. 1645°F. 15 mins. Water 1100°F. 3 hrs. Air	A. A-II (.13C, 4.25 Mn, .52Si, .19.1Cr, 9.4Ni) B. 3/16" HF C. Grinding (.09C, 4.45 Mn, .56Si, .30.1Cr, 9.6Ni) C. AC-5 D. DC REV	A. Not Given B. I 5/32" 1a C. Two layers 1/4" 2a D. Peening - first pass	A. 60°DV 1/16" HF B. 3/16" HF C. Grinding D. Peening - first pass	A. None B. None	1 2100 2 2100	3 2100 4 2100 5 2100 6 2100	3 2100 4 2100 5 2100 6 2100	3 2100 4 2100 5 2100 6 2100	3 2100 4 2100 5 2100 6 2100
A. AD-201 B. 1/16/43 C. KW-175-F D. F.C. Atkins E. Crucible Steel Company F. Chevrolet Motor Co.	A. 3/8" B. R-V (.89Mn, .98Si, .65Cr, .55Ni, .27Mo) C. .27 D. Face 321 Back 321 E. B. Elec. F. 1645°F. 15 mins. Water 1100°F. 2 hrs. Air	A. A-I (.14C, 3.58 Mn, .31Si, .19.7Cr, 10.4Ni, 1.17Mo) B. 3/16" HF C. Grinding A-II (.10C, 4.38 Mn, .71Si, .20.8Cr) B. Arborite C. T102 D. DC REV	A. Not Given B. I 5/32" 1a C. Two layers 1/4" 2a D. Peening - first pass	A. 60°DV 1/16" HF B. 3/16" HF C. Grinding D. Peening - first pass	A. None B. None	1 2100 2 2100	X 2100 X 2100	3 2100 4 2100 5 2100 6 2100	3 2100 4 2100 5 2100 6 2100	3 2100 4 2100 5 2100 6 2100
RESULTS ON CAST IRON TESTS										
A. AD-201 B. 1/16/43 C. KW-175-F D. F.C. Atkins E. Crucible Steel Company F. Chevrolet Motor Co.	A. 3/8" B. R-V (.89Mn, .98Si, .65Cr, .55Ni, .27Mo) C. .27 D. Face 321 Back 321 E. B. Elec. F. 1645°F. 15 mins. Water 1100°F. 2 hrs. Air	A. A-I (.14C, 3.58 Mn, .31Si, .19.7Cr, 10.4Ni, 1.17Mo) B. 3/16" HF C. Grinding A-II (.10C, 4.38 Mn, .71Si, .20.8Cr) B. Arborite C. T102 D. DC REV	A. Not Given B. I 5/32" 1a C. Two layers 1/4" 2a D. Peening - first pass	A. 60°DV 1/16" HF B. 3/16" HF C. Grinding D. Peening - first pass	A. None B. None	1 2100 2 2100	X 2100 X 2100	3 2100 4 2100 5 2100 6 2100	3 2100 4 2100 5 2100 6 2100	3 2100 4 2100 5 2100 6 2100
RESULTS ON STAINLESS STEEL TESTS										
A. AD-201 B. 1/16/43 C. KW-175-F D. F.C. Atkins E. Crucible Steel Company F. Chevrolet Motor Co.	A. 3/8" B. R-V (.89Mn, .98Si, .65Cr, .55Ni, .27Mo) C. .27 D. Face 321 Back 321 E. B. Elec. F. 1645°F. 15 mins. Water 1100°F. 2 hrs. Air	A. A-I (.14C, 3.58 Mn, .31Si, .19.7Cr, 10.4Ni, 1.17Mo) B. 3/16" HF C. Grinding A-II (.10C, 4.38 Mn, .71Si, .20.8Cr) B. Arborite C. T102 D. DC REV	A. Not Given B. I 5/32" 1a C. Two layers 1/4" 2a D. Peening - first pass	A. 60°DV 1/16" HF B. 3/16" HF C. Grinding D. Peening - first pass	A. None B. None	1 2100 2 2100	X 2100 X 2100	3 2100 4 2100 5 2100 6 2100	3 2100 4 2100 5 2100 6 2100	3 2100 4 2100 5 2100 6 2100
RESULTS ON MILD METAL TESTS										
A. AD-201 B. 1/16/43 C. KW-175-F D. F.C. Atkins E. Crucible Steel Company F. Chevrolet Motor Co.	A. 3/8" B. R-V (.89Mn, .98Si, .65Cr, .55Ni, .27Mo) C. .27 D. Face 321 Back 321 E. B. Elec. F. 1645°F. 15 mins. Water 1100°F. 2 hrs. Air	A. A-I (.14C, 3.58 Mn, .31Si, .19.7Cr, 10.4Ni, 1.17Mo) B. 3/16" HF C. Grinding A-II (.10C, 4.38 Mn, .71Si, .20.8Cr) B. Arborite C. T102 D. DC REV	A. Not Given B. I 5/32" 1a C. Two layers 1/4" 2a D. Peening - first pass	A. 60°DV 1/16" HF B. 3/16" HF C. Grinding D. Peening - first pass	A. None B. None	1 2100 2 2100	X 2100 X 2100	3 2100 4 2100 5 2100 6 2100	3 2100 4 2100 5 2100 6 2100	3 2100 4 2100 5 2100 6 2100

TESTS ON REINFORCED IRON CIR.									
TEST NUMBER	DATE OF TEST	TESTING DATA		WELDING PROCEDURE		HEAT SOURCE		LOCATION OF HOLE	
		A. PLATE THICKNESS	B. TYPE NAME	C. COMPOSITION	D. PLATE PREPARATION	E. PLATE POSITION	F. PLATE HEAT TREATMENT	G. PLATE TEMPERATURE	H. PLATE POLARITY
A. AD-207 B. 1/21/43 C. W-95 D. Ford Motor Co. E. Crucible Steel Corp. F. Ford Motor Co.	A. 3/8" B. R-II (1.27Mn-.24Si-.52Cr-.05Ni-.40Mo) C. .27 D. --- E. --- F. 1650°F. 2 hrs. Platen 975°F. 3-1/4 hrs. Air	A. A-I .07C 1.82 Mn.20.09 Cr.9.97Ni 2.00Mo B. Armorize resistal titania DC REV	A. 600SV B. 3/16" C. Flame Cutting	A. Not given B. 1. 3/16" 2. 1 3/16" 3. 1 3/16" C. --- D. ---	A. None B. None	A. 2100 3 1/2 L 2100 3 R 3100 2 R 4200 1 L 4200 1 U	B. 1 15" Imp V 16"	C. Passed radiograph	
A. AD-207 B. 1/21/43 C. W-96 D. Ford Motor Co. E. Crucible Steel Corp. F. Ford Motor Co.	A. 3/8" B. R-II (1.27Mn-.24Si-.52Cr-.05Ni-.40Mo) C. .27 D. --- E. --- F. 1650°F. 2 hrs. Platen 975°F. 3-1/4 hrs. Air	A. A-I .07C 1.82 Mn.20.09 Cr.9.97Ni 2.00Mo B. Armorize resistal titania DC REV	A. 600SV B. 1/4" C. Flame Cutting	A. Not given B. 1. 3/16" 2. 1 3/16" 3. 1 3/16" C. --- D. ---	A. None B. None	A. 2100 1 1/2 L 2100 1 L 3100 1 L 4200 1 L	B. 1 15" Imp V 16"	C. Passed radiograph	
A. AD-346 B. 3/30/43 C. W-19 D. Ford Motor Co. E. Page F. Allegheny Motor Co.	A. 3/8" B. R-II (1.27Mn-.24Si-.52Cr-.05Ni-.40Mo) C. .27 D. --- E. Back 341 F. 1650°F. 2-1/2 hrs. Platen 975°F. 3-3/4 hrs. Air	A. A B. --- C. DC REV	A. 450SV B. 3/16" C. Flame Cutting	A. Copper B. I 5/32" C. I 3/16" 3. 1 5/32" C. 3 hrs. D. Crater cracking and chipping after first pass.	A. None B. None	A. 2100 3 R 2100 3 R 2100 2 R	B. 1 14" Imp V 16"	C. Passed radiograph	
									Steel Metal

32

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Final Accounting

6

Weld Metal

RESTRICTED

TITLE: Welding of Armor-Experimental Report from 1 October 1942 through 31 March 1943

AUTHOR(S): Turkalo, Anna M.; Herres, S. A.

ORIGINATING AGENCY: Watertown Arsenal Lab., Watertown, Mass.

PUBLISHED BY: (Same)

ATI- 38776

REVISED

(None)

ORG. AGENCY ID.

WAL-640/90

PUBLISHING AGENCY ID.

(Same)

DATE	DOC. CLASS.	COUNTRY	LANGUAGE	PAGES	ILLUSTRATIONS
Nov' 43	Restr.	U.S.	Eng.	81	Tables, diagrs

ABSTRACT:

Ballistic shock test results on 1/2 in., 3/8.in., and 1/4 in., thick homogeneous armor "H" plates welded with austenitic electrodes are outlined. Data from string records for 99 welded armor H plates have been tabulated on accompanying charts and tables. Quality of armor plate appears to be the most significant variable for the three thicknesses of plate included in the tabulation. There is little difference in ballistic shock test results between plates welded with the manganese and with the molybdenum modified type of austenitic electrodes. No significant trends for decreased weld cracking during ballistic testing are apparent for any of the variations in joint preparation or welding procedure.

DISTRIBUTION: Copies of this report obtainable from Air Documents Division; Attn: MCIDXD

DIVISION: Ordnance and Armament (22)

SECTION: Armor (5)

SUBJECT HEADINGS: Armor plate, Welded - Stresses
(11530)

ATI SHEET NO.: R-22-5-20

AIR TECHNICAL INDEX
RESTRICTED

Air Documents Division, Intelligence Department
Air Materiel Command

Wright-Patterson Air Force Base
Dayton, Ohio